Doctoral INPhINIT - INCOMING Fellowship Programme

2020 Call for applications

Position: Unveiling the time structure of QCD collectivity

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Centre description

The Galician Institute for High Energy Physics (Instituto Galego de Física de Altas Enerxías, IGFAE) is a joint research institute of the University of Santiago de Compostela and Xunta de Galicia (the Galician Autonomous Government). It was officially created on July 2, 1999. The main goal of the Institute is to coordinate and foster the scientific and technical research in the field of High Energy Physics, Particle and Nuclear Physics and related areas as Astrophysics, Medical Physics and Instrumentation. Of primary importance is the planning and promotion of the relation with large experimental facilities, especially with CERN, GSI/FAIR and the Pierre Auger Observatory at present.

The experimental groups at IGFAE coordinate the Spanish participation in the LHCb Collaboration at CERN, the Spanish participation in the Pierre Auger Observatory, as well as the Spanish participation in the GSI/FAIR nuclear facility. Members of the Institute have a relevant participation in the LHCb upgrade planning, in the LHeC project development and planning, etc. In the last couple of years a new line has also been open with the building of a new facility (LaserPet) at the University of Santiago de Compostela aiming to produce radioisotopes for medical use by a laser-induced plasma accelerator. Moreover, the theory section of the Institute holds an excellent international reputation, with participation in different international committees, invitations to plenary talks and large-impact publications.

Research project and research line description

Recent data on pp and pPb collisions at the Large Hadron Collider at CERN indicate that, in these small collisions systems, many of the characteristics observed in PbPb collisions like azimuthal asymmetries, are present. This finding suggests that some degree of collectivity is already attained in these small systems. Its origin is unclear, and both initial and final state explanations have been proposed. If it is the initial state, the observed phenomena shed light on the characteristics of the wave function of the incoming hadrons and on the behaviour of QCD at large energies and partonic densities. If the final state, it would illuminate on the problem of isotropisation and equilibration in small systems, and on how the macroscopic description eventually applicable emerges from the microscopic dynamics in systems initially very far from equilibrium. The project is focused on the theoretical and phenomenological study of such collisions in order to clarify the origin of collectivity. Both initial and final state explanations will be pursued, based on first principles calculations in perturbative Quantum Chromodynamics and on non-perturbative models. Observables to distinguish between them will be proposed.

The research group - the Particle Physics Phenomenology Group at IGFAE - consists of four professors plus one emeritus full professor, three postdocs and four PhD. students. The group is a world leader in the field of heavy-ion collisions, specifically in the proposal of both initial state explanations in the framework of weak (Color Glass Condensate) and strong coupling QCD (strong models and AdS/CFT), and final state ones (radiative energy loss for energetic partons and rescattering models for quarkonium). It is strongly implicated in the organisation and development of the main conferences in the field, and in future projects like HL/HE-LHC or the FCC. It is in a very close relationship with all the large experimental collaborations at the LHC.

Job description

The candidate will work under the supervision of one or several of the researchers in the group, on one of the following topics:

- Initial state explanations of the apparent collectivity observed in pp and pPb collisions in the framework of the Color Glass Condensate. This is a weak coupling but non-perturbative effective field theory that allows first principle calculations of the wave function of hadrons and of production and correlations of several particles. Radiative corrections will be systematically computed, applied to observables that will be measured at the LHC like jets and photons. The evolution with energy of the correlations and of the density matrix of the system will be examined.

- Final state explanations for quarkonium production in small systems, like the transport model realisation given by comovers. The different excited states of charmonium and bottomonium will be analysed and a unified explanation that considers both initial and final state effects will be pursued. The relation and interplay with the effective temperature and the different time scales in the process will be examined.
- The phenomena of radiative energy loss and its effects on the yields of high-energy particles and jets, in small systems. High-energy particle and jet suppression, known as jet quenching, is apparently absent in small systems, being the only characteristic observed exclusively in heavy-ion collisions. The origin of such smallness and the possibilities that energy loss phenomena offer to study the different times in the process will be analysed.

The candidate is expected to acquire a deep theoretical and phenomenological knowledge of the respective problems. Both analytical and numerical skills will be developed, including modern techniques for jet studies that comprise pattern recognition and machine learning. Publications in top peer-reviewed journals and presentations in international conferences are expected to follow the development of the project.